MICROBIOLOGICAL WATER QUALITY OF EAGLE LAKE

SOUTH RIVER

PARRY SOUND DISTRICT

APRIL 1979

Ministry of the Environment

Ontario

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SUMMARY

An intensive microbiological survey was conducted from August 17 to 24, 1978 to determine and evaluate the existing microbiological water quality of Eagle Lake. The results showed that the water quality was generally good during the survey period. However, localized areas of bacteriological water quality deterioration were detected near some cottages (Stations 2, 46 and 49) and several inflowing stream locations (Stations 13, 41, 42 and 43). The densities of total coliforms and fecal streptococci in particular were higher in these areas than the rest of the lake. The results also indicated that bacterial contamination at these problem sites was predominately of non-human type and originated in surface runoffs from nonpoint sources.

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1.0 INTRODUCTION

Recreational lakes in the Province of Ontario conventionally receive heavy usage in terms of cottage development, camp and picnic sites, trailer parks and provincial parks. The increasing use of these areas for recreational activities tends to exert an impact on the environment that may result in degraded water quality.

In general, recreational lakes water quality deterioration mainly occurs due to microbiological contamination and/or undesirable and excessive growth of algae and aquatic plants (eutrophication). These problems may originate from a common pollution source, but their consequences are quite different. The effects of nutient enrichment (i.e. eutrophication) may appear slowly and persist for long periods, however, microbiological contamination through raw/inadequately treated sewage poses an immediate potential public health hazard if the water is used for drinking, bathing and swimming. It is imperative, therefore, to maintain good water quality in waters which are increasingly and heavily used for a variety of recreational activities.

A comprehensive study of Eagle Lake (Machar Township, Parry Sound District) was undertaken by the Ministry of the Environment in August 1978 in response to the complaints and concerns, from the township representatives, cottagers associations and local residents, regarding the apparently changing water quality of the lake and the constant pressure for additional shoreline development and park expansion. As a part of this study, an eight-day microbiological survey was carried out to determine and evaluate the existing microbiological water quality in Eagle Lake.

2.0 DESCRIPTION OF THE STUDY AREA

Eagle Lake is located 10 kilometers west of the Town of South River (and 24 kilometers northwest of the Town of Sundridge) in the Township of Macher, Parry Sound District. It is accessible from Highway No. 11.

Eagle Lake has a shoreline of 44.3 kilometers and a surface area of 999.7 hectares. The lake consists of two basins - one to the northwest and the other to the southeast, but there is little interaction between these basins. The maximum depth of the lake is 21.9 meters and the mean depth is about 6.1 meters. The drainage basin area of the lake is approximately 3785 hectares. A flushing rate of 0.41 to 0.43 times per year has been calculated for Eagle Lake. There are several minor inflowing streams scattered around the perimeter of the lake. The major outflow of Eagle Lake is the Distress River, located in the southern basin (Station 5).

The shoreline in both the northern and southern portions of the lake is generally well developed (moderate to heavy density) with a uniform distribution of approximately 311 cottages and 3 resorts (Figure 1). A 265 unit provincial park (Mikisew), including three small beaches, is located in the southern basin of the lake. Eagle Lake is primarily used for recreational activities such as swimming, water skiing, boating, fishing and cottaging. In addition, most cottagers use the lake as a source of domestic water supply.

3.0 DESIGN OF THE SURVEY

3.1 Sampling Locations and Frequency

The southern and northern basins of the lake were examined separately over a period of four consecutive days during August 17 to 24, 1978.

The microbiological sampling stations were situated along the provincial park, in areas considered representative of the various shoreline

developments on the lake, at the inflows, mid-lake and outflow locations. Samples were collected seven to ten meters from the shore and one meter below the surface at 50 shoreline and 3 mid-lake stations (Figure 1). Water samples, obtained manually using presterilized (autoclaved) 500 ml polycarbonate bottles, were stored on ice and transported to the mobile laboratory where they were analyzed within 2 to 6 hours of collection.

3.2 Microbiological Parameters and Methods

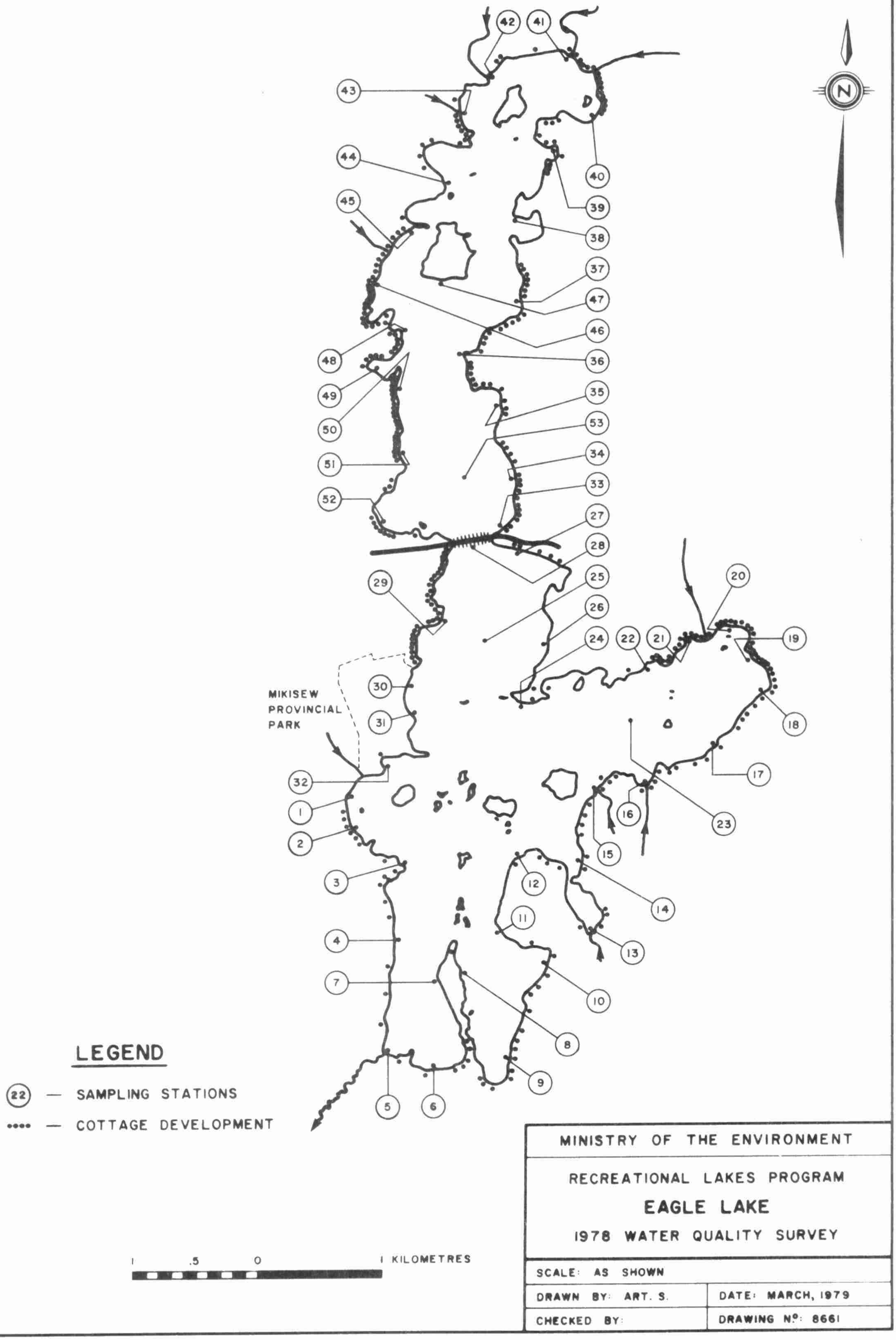
All samples were analyzed for the detection and enumeration of pollution indicator organisms (viz. total coliforms, fecal coliforms and fecal streptococci), *Pseudomonas aeruginosa* and heterotrophic bacteria. In addition, some samples were examined for the presence of *Candida albicans*.

The three indicator organisms are all indigenous to man and other warm-blooded animals, and are generally found in large numbers in their feces. Since many diseases common to man can be transmitted by feces, the probability of occurrence of these diseases is highest in areas where the water is contaminated with fecal material. These indicator organisms are used in water quality assessment to detect and indicate contamination from fecal material and hence the potential presence of pathogens.

Pseudomonas aeruginosa is recognized as a human (opportunistic) pathogen responsible for a diverse group of diseases including skin and upper respiratory infections and *otitis externa*, an outer ear infection (1). This organism is also found in feces and can be readily isolated from raw sewage samples. In recent years, *P. aeruginosa* has also been used as an indicator of fecal pollution (2).

Candida albicans (a yeast) constitutes a portion of the body's normal saprophytic microflora, but under appropriate conditions is an opportunistic pathogen causing a number of superficial and skin infections. It is common in human/animal feces and raw sewage and has been found in both marine and fresh waters. Recently it has been suggested that *C. albicans* be considered as a potential indicator of water quality (3).

FIGURE 1 - LOCATION OF MICROBIOLOGICAL SAMPLING STATIONS AND AREAS OF SHORELINE DEVELOPMENT ON EAGLE LAKE.



Heterotrophic bacteria are those bacteria which require organic carbon for their growth. The densities of these bacteria in water are influenced by the concentrations of organic nutrients and therefore may be a measure of the degree of organic enrichment in a given body of water.

The densities of total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS) were determined using the membrane filtration (MF) technique. The methods used for the estimation of these pollution indicator bacteria are described in detail in the Ministry of the Environment's 'Handbook of Analytical Methods for Environmental Samples', Volume 2 (4). The levels of P. aeruginosa were ascertained by the MF technique as described by Levin and Cabelli (1). The MF procedure outlined by Buck and Bubucis (3) was employed for the detection of C. albicans. The levels of heterotrophic bacteria (HB) were obtained using the spot plate technique as described by Young (5). For all MF analyses, Gelman GN-6, 47 mm, 0.45 µm, white, gridded and autoclave-sterilized membrane filters were used.

3.3 Statistical Methods

The assessment of water quality cannot be determined accurately from a single water sample as the microbial populations fluctuate tremendously in response to changing environmental conditions. Therefore, microbiological surveys require the collection of many samples from several stations over a designated period of time (3 to 5 days). The large amount of data generated is reduced by calculations to meaningful and easily managed statistics.

All microbiological data (1072 determinations on 212 samples) collected during the 8-day survey of Eagle Lake were transformed to logarithms (base 10), and all further analyses were done using the transformed data. The geometric mean (the most suitable central value) and variance were calculated for the values of TC, FC, FS, Pseudomonas aeruginosa, and Heterotrophs at every station thereby providing concise valid data. These data were then analyzed by a one-way analysis of variance and Bartlett's Test of Homogeneity to determine

statistically significant variation in the (microbial) densities between stations or groups of stations. Using this procedure, the data from each station were tested against that of every other station until all stations with similar geometric mean concentrations were separated into individual groups (e.g. Group A, B).

The group results and those for individual stations were identified by different stippling. Within each stippled area, the group geometric mean applied for each type of bacteria at all stations unless otherwise indicated by individual station values. In this manner, significantly different areas of the lake were differentiated as to the degree and level of microbial contamination and related to existing shoreline development or usage.

4.0 RESULTS AND DISCUSSION

The results of analysis of variance of all microbiological data and grouping of stations/areas are summarized in Appendices I-V.

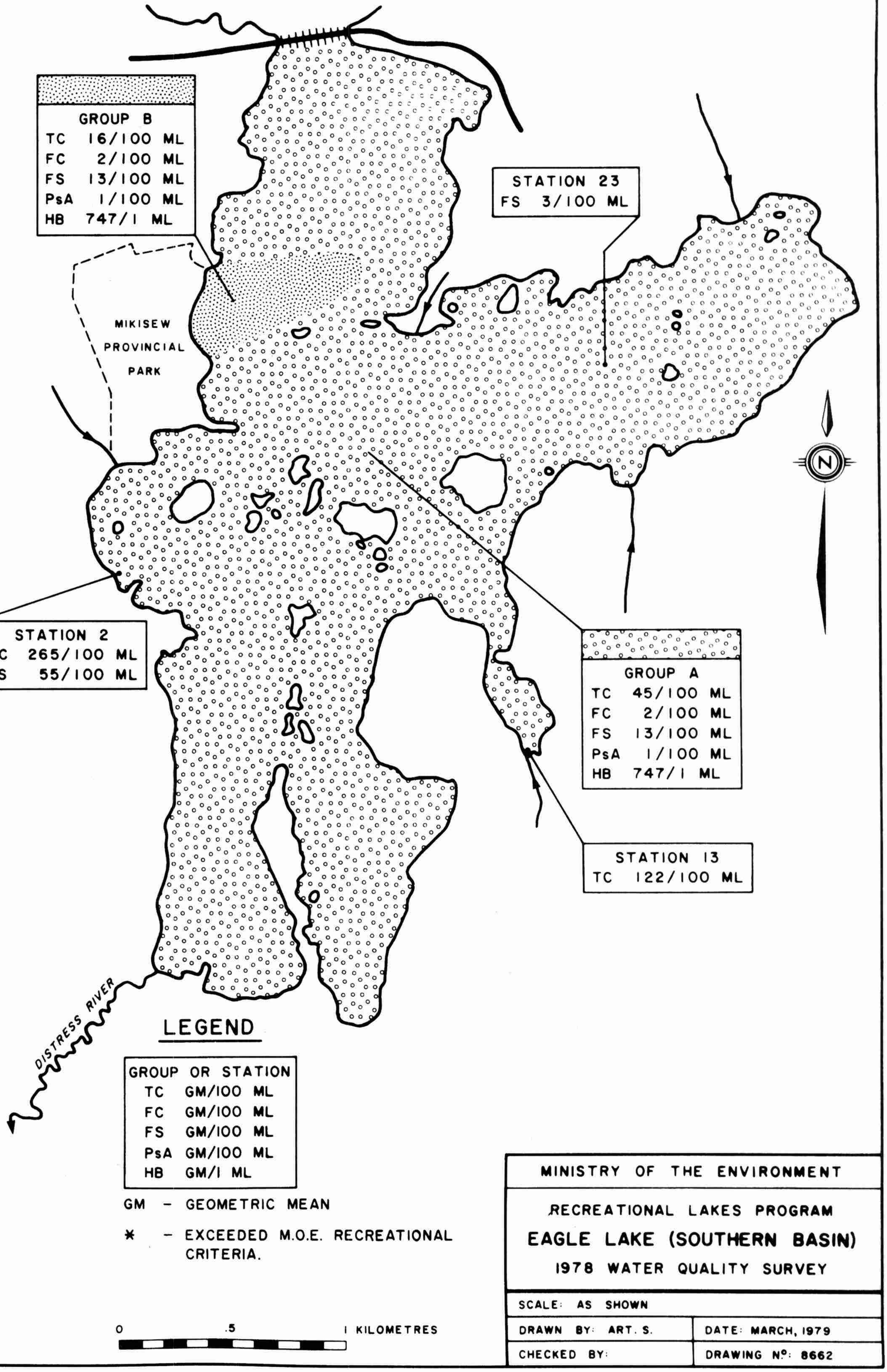
The microbiological water quality of Eagle Lake during the August 1978 survey was generally good and, with few exceptions, was within the Ministry of the Environment Microbiology Criteria for Total Body Contact Recreational Use. According to the criteria, "where ingestion is probable, recreational waters can be considered impaired when the total coliform (TC), fecal coliform (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month including samples collected during weekend periods". *

4.1 Southern Basin

The densities of fecal pollution indicator bacteria were generally low at a majority of the stations in the southern basin of the lake. The geometric means (GM) for various parameters were 45 TC, 2 FC, 13 FS and 1 P. aeruginosa per 100 ml (Group A, Figure 2). Although most of the stations located on the

* Guidelines and Criteria for Water Quality Management in Ontario, Ministry of the Environment.

FIGURE 2 - DISTRIBUTION OF BACTERIA IN THE SOUTHERN BASIN OF EAGLE LAKE (AUGUST 17 TO 20)



western part of the southern basin also showed bacterial populations similar to those for Group A, a midlake (Station 25) and a shoreline (Station 30) location had low (16/100 ml) TC densities (Group B, Figure 2). Furthermore, another midlake station (Station 23) recorded the lowest (3/100 ml) FS densities.

The highest levels of TC (265/100 ml) and FS (55/100 ml) were observed at Station 2, located on the southwest shore near a cottaged area. The relative concentrations of FC and FS indicated that contamination at this site probably originated from non-human sources in the surface runoffs.

In general, inflows usually have higher bacterial populations than the rest of the lake since they transport materials (including human and animal wastes) from the surrounding land into the lake. At Station 13 (an inflow station), the bacterial densities were generally similar to those of Group A with the exception of higher TC levels (122/100 ml).

The populations of heterotrophic bacteria ranged from 341 to 1600/ml, with a GM of 747/ml (Figure 2, Appendix V). Candida albicans was not detected in water samples collected from three bathing beach locations (Stations 6, 30 and 31).

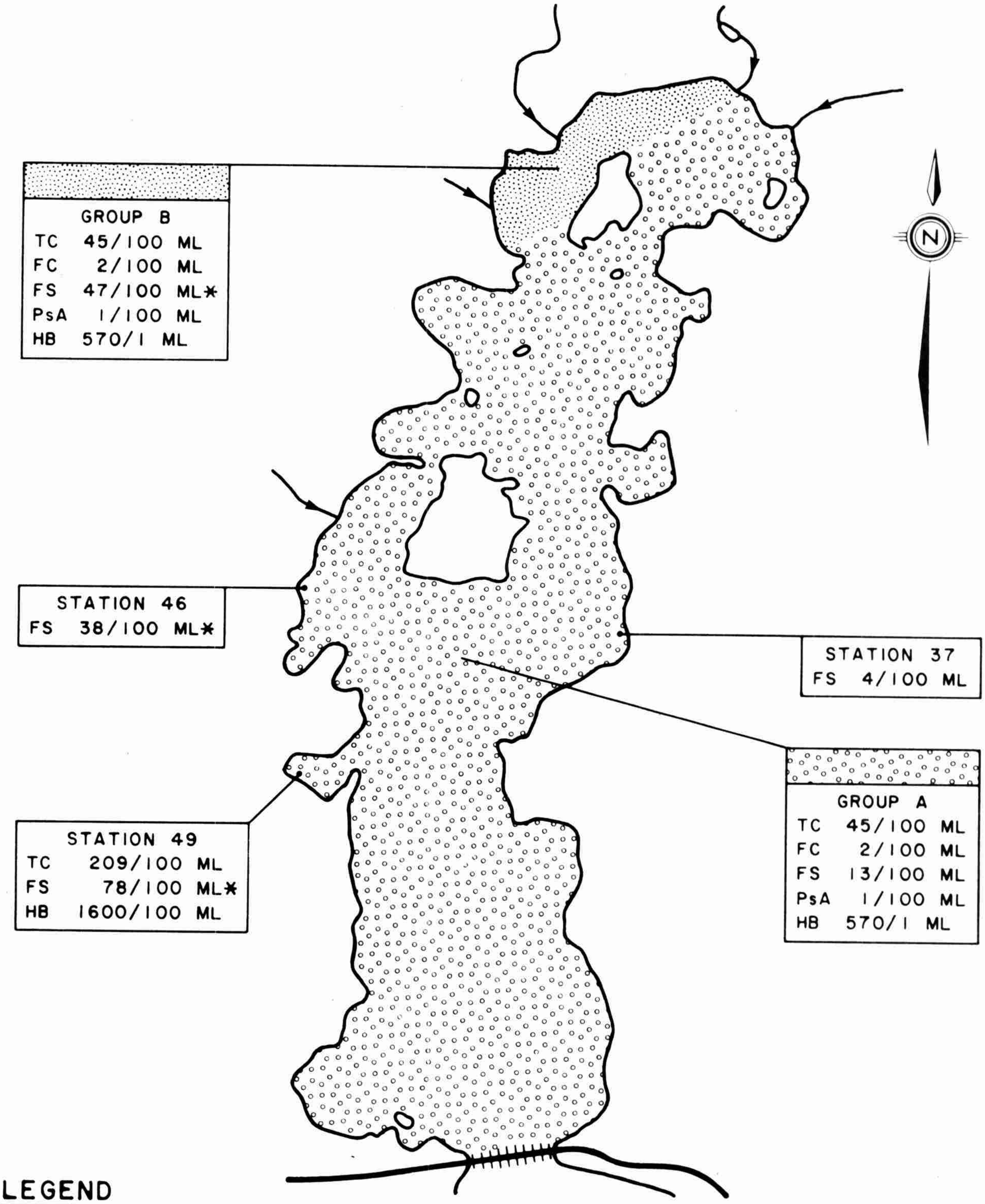
4.2 Northern Basin

The northern basin of Eagle Lake also showed low bacterial populations and, at most of the stations, densities of indicators were similar to those observed in the southern basin. The GM bacterial concentrations in the northern basin were 45 TC, 2 FC, 13 FS and 1 P. aeruginosa per 100 ml (Group A, Figure 3).

At the three inflowing stream locations (Stations 41, 42 and 43), high FS levels (47/100 ml) were observed (Group B, Figure 3). However, the TC, FC and P. aeruginosa densities at these stations were not significantly different from those of Group A.

In Figure 3, the highest densities of TC (209/100 ml) and FS (78/100 ml) were obtained at Station 49, situated adjacent to a cottaged area on the west

FIGURE 3 - DISTRIBUTION OF BACTERIA IN THE NORTHERN BASIN OF EAGLE LAKE (AUGUST 20 TO 24)



LEGEND

GROUP OR STATION	
TC	GM/100 ML
FC	GM/100 ML
FS	GM/100 ML
PsA	GM/100 ML
HB	GM/1 ML

GM - GEOMETRIC MEAN

* - EXCEEDED M.O.E. RECREATIONAL CRITERIA.

0 .5 1 KILOMETRES

MINISTRY OF THE ENVIRONMENT	
RECREATIONAL LAKES PROGRAM **EAGLE LAKE (NORTHERN BASIN)** 1978 WATER QUALITY SURVEY	
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CHECKED BY:	DRAWING Nº: 8663

shore. The lowest FS concentrations were recorded at Station 37, located beside a cottage on the east shore. The relative populations of FC and FS at the inflows and cottaged locations suggested that the pollution was mainly of non-human source and probably originated in rural runoffs.

In the northern basin, the densities of heterotrophic bacteria were slightly lower than those observed in the southern basin of the lake. The HB levels at most stations varied between 408 to 810/ml, with a GM of 570/ml (Figure 3, Appendix V). The highest HB concentrations (1600/ml) were observed at Station 49, situated near a cottage.

Water samples from the northern basin stations were not analyzed for the presence of C. albicans.

5.0 CONCLUSIONS

The northern and southern basins of Eagle Lake appeared to have relatively similar microbiological water quality which was generally good throughout the eight-day survey period as determined by low levels of fecal pollution indicator and heterotrophic bacteria. However, there were localized areas of bacteriological water quality degradation at some inflowing stream locations (Stations 13, 41, 42 and 43) and a few cottaged areas (Stations 2, 46 and 49). Bacterial concentrations, especially those of total coliforms and fecal streptococcci, were higher in these areas than the rest of the lake. In addition, at these sites, the FS densities exceeded the MOE Water Quality Criteria for Recreational Use. However, these were the only instances where criteria violation occurred and the data indicated that the pollution in these localized areas was of non-human type and mainly originated from nonpoint sources.

In summary, the effect of existing development on microbiological water quality of Eagle Lake was minimal as the bacterial levels were not appreciably greater than those found in an undeveloped (Jerry) lake (6).

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7.0 ACKNOWLEDGEMENTS

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APPENDICES

EXPLANATION OF TERMS IN APPENDICES 1 - V

GM - the geometric mean of the bacterial level.

t - the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

Log GM - the logarithm (base 10) of the geometric mean.

S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N - the number of values in the mean.

APPENDIX 1 - ANALYSIS OF VARIANCE SUMMARY FOR TOTAL COLIFORMS PER 100 ML

GROUPS	Log GM	SE	N	GM
SOUTHERN BASIN (August 17-20 Survey)				
Group A				
(All Stations Except 2, 13, 15, 30	1.6561	0.0270	112	45.3
Group B				
Stations 25, 30	1.1972	0.0705	8	15.7
Station 2	2.4236	0.1305	4	265.2
Station 13	2.0871	0.0361	4	122.2
NORTHERN BASIN (August 21-24 Survey)				
Group A				
All Stations Except 49	1.6541	0.0511	84	45.1
Station 49	2.3201	0.1466	4	209.0

APPENDIX II - ANALYSIS OF VARIANCE SUMMARY FOR FECAL COLIFORMS PER 100 ML

GROUPS	Log GM	SE	N	GM
SOUTHERN BASIN				
(August 17-20 Survey)				
Group A				
All Stations	0.3118	0.0307	128	2.1
NORTHERN BASIN				
(August 21-24 Survey)				
Group A				
All Stations	0.2078	0.0335	88	1.6

APPENDIX III - ANALYSIS OF VARIANCE FOR FECAL STREPTOCOCCUS PER 100 ML

GROUPS	Log GM	SE	N	GM
SOUTHERN BASIN				
(August 17-20 Survey)				
Group A				
All Stations Except 2, 23	1.1219	0.0372	120	13.2
Station 2	1.7406	0.1346	4	55.0
Station 23	0.4519	0.1504	4	2.8
NORTHERN BASIN				
(August 21-24 Survey)				
Group A				
All Stations Except 37, 41, 42, 43, 46, 49	1.1164	0.0458	64	13.1
Group B				
Stations 41, 42, 43	1.6682	0.0616	12	46.6
Station 37	0.6021	0.2129	4	4.0
Station 46	1.5833	0.3517	4	38.3
Station 49	1.8926	0.0559	4	78.1

APPENDIX IV - ANALYSIS OF VARIANCE SUMMARY FOR PSEUDOMONAS AERUGINOSA PER 100 ML

GROUPS	Log GM	SE	N	GM
SOUTHERN BASIN				
(August 17-20 Survey)				
Group A				
All Stations	0.0073	0.0044	128	1.0
NORTHERN BASIN				
(August 21-24 Survey)				
Group A				
All Stations	0.0047	0.0034	88	1.0

APPENDIX V - ANALYSIS OF VARIANCE SUMMARY FOR HETEROTROPHIC BACTERIA PER 100 ML

GROUPS	Log GM	SE	N	GM
<u>SOUTHERN BASIN</u>				
(August 17-20 Survey)				
Group A				
All Stations	2.8731	0.0324	126	746.6
<u>NORTHERN BASIN</u>				
(August 21-24 Survey)				
Group A				
All Stations Except 49	2.7551	0.0213	84	568.9
Station 49	3.2161	0.0372	4	1644.8